

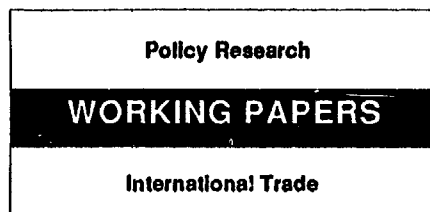
International Economics Department
The World Bank
May 1993
WPS 1136

The Dynamic Behavior of Quota License Prices

Theory and Evidence from the Hong Kong Apparel Quotas

Kala Krishna
and
Ling Hui Tan

Welfare evaluations and reform recommendations in many studies may need to be reworked, to account for the possibility that the quota license market — usually assumed to be perfectly competitive for Hong Kong — is not perfectly competitive.



WPS 1136

This paper — a product of the International Trade Division, International Economics Department — is part of a larger effort in the department to assess the burden imposed on developing country exporters by trade barriers. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Dawn Gustafson, room S7-044, extension 33714 (May 1993, 52 pages).

Empirical studies of the welfare consequences of quotas often assume perfect competition everywhere. If this assumption is not valid, welfare estimates and policy recommendations may err dramatically. The popular press often argues that market power is being exercised in markets constrained by import quotas.

Krishna and Tan develop a framework for testing the hypothesis of perfect competition in the market for apparel quota licenses. Drawing on simple models, they predict the behavior of license prices, taking into account four influences on prices: scarcity value, option value, renewal value, and asset value. They explore the effect of imperfections in the license market on license price paths.

They test allegations that there is price fixing in the market for Multi-Fibre Arrangement (MFA) apparel quota licenses in Hong Kong. (Hong Kong often serves as a benchmark case for the welfare consequences of the MFA.) They use monthly data on license prices and use rates to test for the presence of imperfect competition. They argue that a concentration of license

holding could affect both the supply side and the demand side, by affecting the costs of search.

These results accord well with their theoretical discussion, in which they point out that license use and price paths with imperfect competition in the license market may be quite different from the corresponding paths in the case of perfect competition — even though the total use of licenses is the same.

They estimate the structural demand and supply equations of the model, which provide further evidence of imperfect competition in the license market. In particular, the intra-year path of quota license prices and of quota use are found to be affected by concentration in license holdings.

The results, in short, suggest that market power exists in Hong Kong's quota license market. Hong Kong is often considered the prime example of perfect competition, so this has major implications for other developing countries.

The Policy Research Working Paper Series disseminates the findings of work under way in the Bank. An objective of the series is to get these findings out quickly, even if presentations are less than fully polished. The findings, interpretations, and conclusions in these papers do not necessarily represent official Bank policy.

**THE DYNAMIC BEHAVIOR OF QUOTA LICENSE PRICES:
THEORY, AND EVIDENCE FROM THE HONG KONG APPAREL QUOTA MARKET**

by

**Kala Krishna
Tufts University and NBER**

and

**Ling Hui Tan
Harvard University**

FOREWORD

Quotas and other nontariff barriers have become important restrictions on the exports of developing countries. Economists have long been concerned about the increasing use of these measures since they lack transparency and are frequently used to discriminate between suppliers. While some indication of the restrictiveness of a system of quotas can be obtained where markets in quota licenses exist, there are relatively few open markets for quotas and prices in these markets are volatile.

In recent research, Kala Krishna and Ling Hui Tan have highlighted another potentially important consequence of nontariff barriers. They can have major implications for the competitive structure of markets and hence for the distribution of quota rents.

In the two studies included in this paper, Krishna and Tan explore an additional consequence of import quotas: their implications for the dynamic behavior of import quota prices. An understanding of this behavior is essential if the behavior of quota license prices is to be understood. Without it, economists are unable to be confident that their assessment of the consequences of an import quota system are soundly based.

The first study in this Working Paper provides a quite general theoretical framework for analyzing the dynamic behavior of license prices. This framework takes into account common features of such licenses, including their applicability for a specific period and "use it or lose it" provisions, but is quite general with respect to commodities. The second study draws on this theoretical framework to specify an empirical model of one of the most important cases of import quotas; those imposed on exports of apparel from developing countries under the Multi-fibre Arrangement.

Further work on this topic is in progress and we expect that it will ultimately lead to a substantial improvement in our understanding of this important topic.

Ron Duncan
Chief
International Trade Division
World Bank

I. LICENSE PRICE PATHS: THEORY¹

I.1. Introduction

In a static, perfectly competitive model, it is well understood that a quota license has a scarcity value. This arises because a binding quota raises the domestic price of the restrained good above the world price, creating profits equal to this price difference for the license holders. The size of the price difference depends on the extent of scarcity created by the quota in the domestic market. We call this the *scarcity component* of the license price.

In dynamic settings, the license price has two additional components. Both these are related to the property that a license is valid for an entire year. They are the *asset market component* and the *option value component*. A quota license can be viewed as an asset with a life of one year. Like any other asset, the price path of the license must be such that the license is held voluntarily. For this to occur in a world without uncertainty, the price of the asset must rise at the rate of interest as the latter represents the opportunity cost of holding the asset. Therefore, the asset market component predicts that the price of a license will rise over the year.

The third component of the license price is the option value component. At any point in time during the year, a quota holder can either use the license (by shipping the goods or by making a temporary transfer to someone else) or defer the license application in the hope of a

¹ We are grateful to the World Bank for research support, and to Sweder van Wijnbergen for comments on an earlier draft.

higher price in the future if demand realizations are high. The value of a license held today, before the state tomorrow is known, can exceed the expected price of the license at any time in the future since a license allows the decision on use to be deferred till the state is known. In other words, a quota license has an "option" value.

In addition, the details of quota allocation mechanism can create other complications which affect license prices. For example, quota allocations may be tied to past performance, where firms with a high quota utilization are rewarded with an increased allocation in the next period.¹ This creates a *renewal value component* of the license price. In Hong Kong, for example, a legal market exists for both temporary and permanent transfers of licenses to export textiles and apparel under the Multi-Fibre Arrangement. Under a permanent transfer, the seller relinquishes the use of the license in the current and all future periods. Under a temporary transfer, however, the seller loses the use of the license in the current period but retains renewal rights. This can create negative prices for temporary transfers of licenses as pointed out by Anderson (1987), and further discussed in Eldor and Marcus (1988).

The paper is organized as follows. Section 2 provides some theoretical foundations for the different components of the license price, namely the scarcity component, the asset market component, the option value component, and the renewal component. Section 3 relates our work to the existing literature. Section 4 contains some concluding remarks.

I.2. Some Simple Models

In this section, we present some simple models which help to explain the forces underlying license price paths during the quota period. We will first present a simple model which focuses on the option value component. Next, we use this model to look at the implications of "use-it-or-lose-it" restrictions on the price of temporary versus permanent transfers. We then argue that this model is a very special one and that the option value component disappears in interior solutions when the license price is made endogenous. Finally, we consider the license utilization path when there is strategic interaction between the license holders.

Model 1:

Let us consider trade between the U.S. and Hong Kong. We assume, for simplicity, that there are no transport costs or tariffs, and that the quota is imposed on a homogeneous good. We further assume that the U.S. price of the good in question can take on only two exogenously given values: a^H (high price) and a^L (low price). This would be the case if demand in the U.S. is uncertain and if Hong Kong supply is such a small part of total supply to the U.S. market that any change in the supply from Hong Kong would not affect the U.S. price.

Similarly, we assume that the supply price from Hong Kong is exogenously given and fixed at S . In other words, we are assuming that the U.S. market is a small enough part of the total sales of Hong Kong that changes in supply to the U.S. do not affect the supply price in Hong Kong. This assumption of infinite elasticity of supply and demand is a crucial one since

it makes the value of using a license in any state an exogenous variable. Thus, if U.S. demand is high², the value of using a license is $L^H = a^H - S$; if U.S. demand is low, the value of using a license is $L^L = a^L - S$. Let $a^H > a^L$, and assume that $L^L > 0$, that is, $S < a^L$. The scarcity component of the license price is reflected in these values. It is due to the presence of trade restrictions that there exists a difference in the U.S. demand price and the Hong Kong supply price for this good. The more restrictive the trade policy is, the greater this difference will be.

Suppose the quota license is valid for three time periods. At each point in time, there is a realization of demand, either high or low, which we call the "good" state and the "bad" state respectively. The "good" state (denoted by the superscript H) is assumed to occur with probability π and the "bad" state (denoted by the superscript L) with probability $(1-\pi)$. The expected value of using a license in any given time period is therefore a constant and equals $E(L)$ where:

$$E(L) = \pi L^H + (1-\pi)L^L. \quad (1)$$

After the state is realized, the holder of a license decides whether or not to use the license. The stream of choices and values is depicted in Figure 1. As usual, the system is solved backwards. In Period 3, if the license is not used, the payoff is zero. If it is used, the payoff is the value of the license in the state realized. Since we assume that both L^H and L^L are non-negative, all available licenses will be used in the final period. The expected license price in Period 3, $E(L_3)$, is thus $E(L)$.

If Period 2 is a good state, all the licenses will be used, since $L^H > \delta E(L_2)$ where δ is the discount factor. If Period 2 is a low demand state, then as long as δ is not too small, so that $L^L < \delta E(L_2)$, none of the licenses will be used.³ The lowest price at which any transaction will occur is $\delta E(L_2)$ and this is the value of owning a license in the low demand state, not L^L . If the discount factor is small enough, licenses will be used in both states. Thus, at the beginning of Period 2, before uncertainty about the state of nature is resolved, the value of a license will equal $E(L_2)$, where:

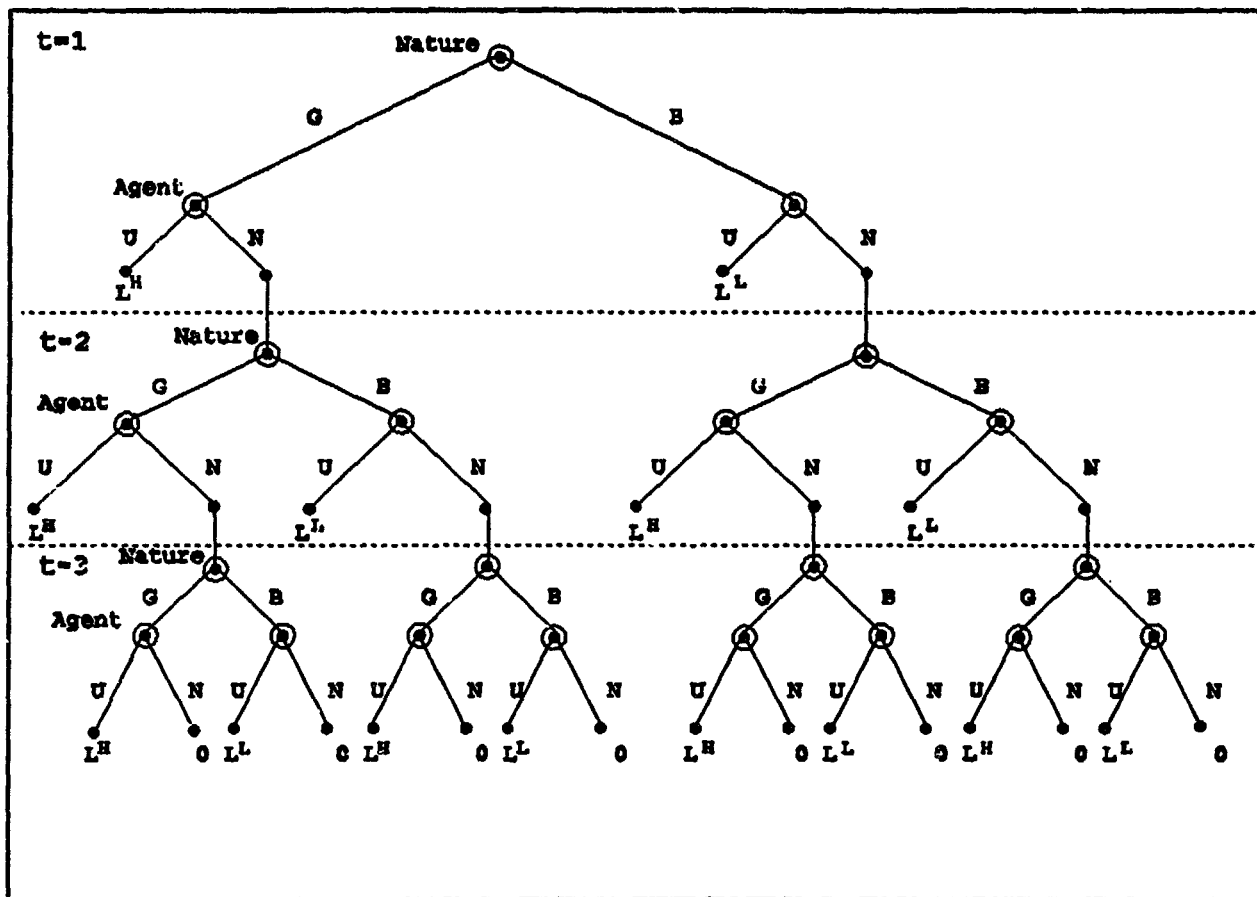
$$E(L_2) = \pi L^H + (1 - \pi) \max[L^L, \delta E(L_2)]. \quad (2)$$

Similarly in Period 1, if a good state occurs, all the licenses will be used since $L^H > \delta E(L_2)$. If a bad state occurs and $L^L < \delta E(L_2)$, no licenses will be used but the value of a license is $E(L_2)$, and not L^L . If $L^L > \delta E(L_2)$, then all licenses are used and the value of a license is L^L . Before uncertainty is resolved in Period 1, therefore, the expected value of a license, $E(L_1)$, will be given by:

$$E(L_1) = \pi L^H + (1 - \pi) \max[L^L, \delta E(L_2)]. \quad (3)$$

The option value arises because the license holder can defer a decision on whether or not to use the license until after the uncertainty is realized. Deferring this decision has no value if there is no choice left as to whether or not to use the license, or if the optimal decisions are not state-contingent so that the choice is effectively worthless. For example, one reason why decisions may be state-independent would be if the discount factor is so small that periods in effect

FIGURE 1: Decision Tree for Quota Utilization in a Three Period Model



separate, and all the licenses are used at the beginning, irrespective of the demand state. Another reason, explored later, is that endogenous forces may make both using and not using the license equally attractive.

In Period 3, using the license is the only sensible choice so there is no option value to a license. In Periods 1 and 2, however, it may be valuable to be able to defer decisions on use

until after the uncertainty is resolved. If the optimal strategy involves such a state-contingent choice (e.g., holding the license in bad states and using it in the first good state), then an option value component exists.

The option price component at any given period is given by the difference between the expected license price before the resolution of uncertainty and the expected license price before the resolution of uncertainty subject to the constraint that a decision on use is made now.⁴ The latter price is given by $E(L)$. Thus, the option price component⁵ equals $E(L_i) - E(L)$ in Period i for $i=1$ or 2 ; there is no option price component in Period 3.

Note that the license price falls over time. This is because the option price component falls over time. For example, with N periods, $\delta=1$, and $L^L = 0$, the value from holding on to a license in a bad state at time t equals L^H times the probability that at least one good state will occur in the remaining periods. This equals L^H times one minus the probability that all the remaining periods have a bad state realized. This value falls over time.

For $N = 3$, $\delta \in (0,1)$, and $L^L = 0$, $E(L)$ equals πL^H . Also:

$$E(L_1) = \pi L^H \{1 + \delta(1 - \pi) + [\delta(1 - \pi)]^2\}. \quad (4)$$

The difference between $E(L_1)$ and $E(L)$ is the option value component. This equals the discounted expected value of a good state occurring some time in the future. Similarly, in Period 2:

$$E(L_2) = \pi L^H [1 + \delta(1 - \pi)]. \quad (5)$$

The difference in this and $E(L)$ is the option value component in Period 2. Notice that the option value component is greater in earlier periods since more periods remain in which the license can be used. In the first two periods, the license holder has the option of not using the license, and this option has value. In the third (terminal) period, this option value disappears.

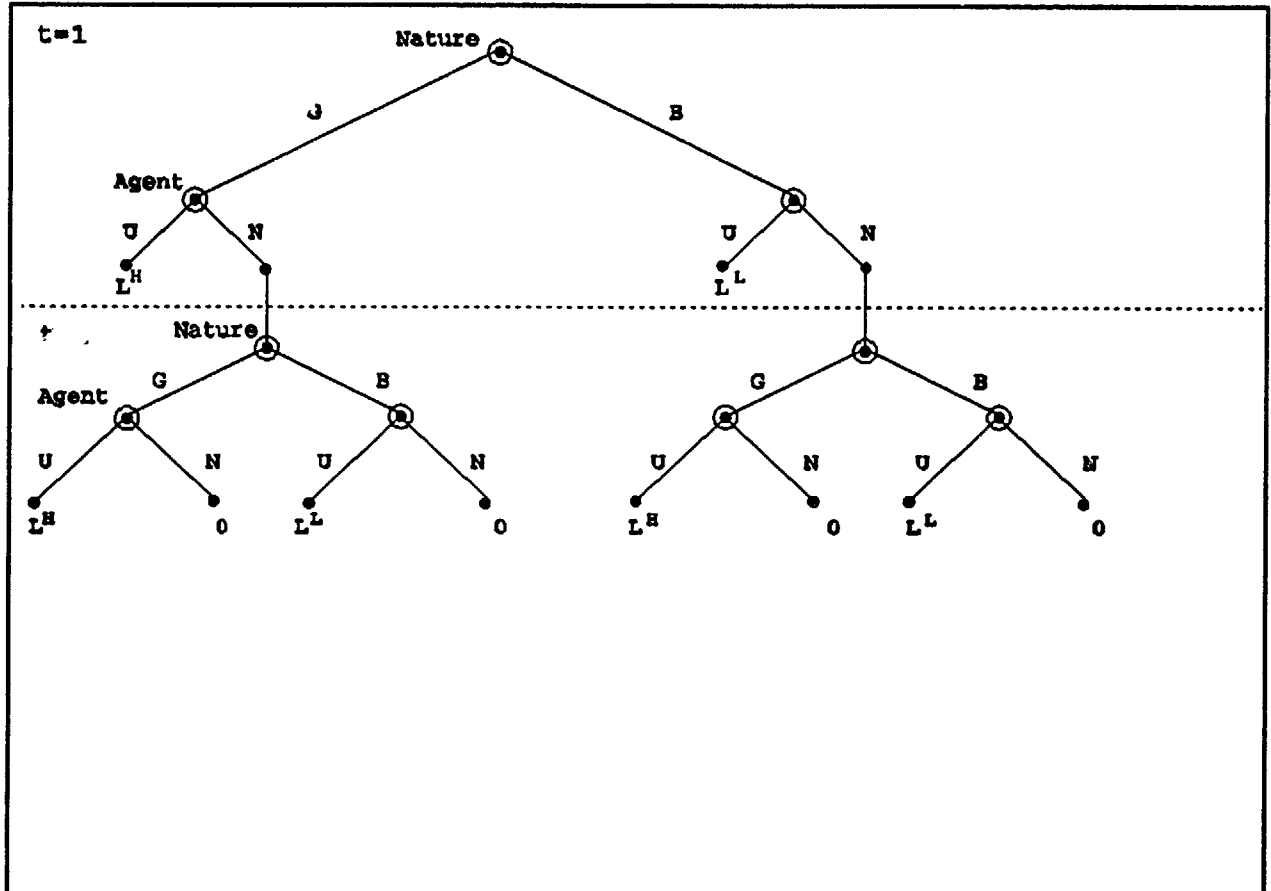
To summarize, the option value component of the license price exists because quota licenses are issued at the beginning of Period 1 and are valid for three periods. The value of a license prior to any information being revealed exceeds the expected price of the license at any time in the future since a license allows the decision on use to be deferred until the state is known.

Model 2:

Here we incorporate the effect of "use-it-or-lose-it" policies on the value of a quota license. Consider a model analogous to Model 1 with two periods in each quota year, but with the twist that using a license leads to obtaining a new license in the next quota year. Denote the value of a new license by R .

For simplicity, we use a two period version of Model 1, which is illustrated in Figure 2. In Period 2 of year 1, if a good state occurs, and the license is used, the holder obtains the license price as well as the (discounted) value of a new license in the next quota period, i.e., $L^H + \delta R$; the holder obtains nothing if the license is not used. If a bad state occurs, using the license yields $L^L + \delta R$, while not using the license again results in zero gain.

FIGURE 2: Decision Tree for a Two Period Model



In Period 1, if a good state occurs and the license is used, the license owner obtains $L^H + \delta^2 R$. If the license is not used, we go to Period 2 and nature moves, yielding a good or a bad realization. The payoffs if the bad state occurs in Period 1 are analogously defined. Note that, by recurrence, R must equal the value of holding a license at $t=1$ before uncertainty is realized, denoted by $E(L_1)$.

The problem is then solved backwards as usual. Since a license can always not be used, $R \geq 0$. In the last stage, therefore, licenses are always used as long as $L^L + \delta R > 0$. We will assume for the time being that this is so. Irrespective of the realization in the first period, the value of holding a license in the second period before the state is realized is denoted by $E(L_2)$ where:

$$\begin{aligned} E(L_2) &= \pi(L^H + \delta R) + (1 - \pi)(L^L + \delta R) \\ &= E(L) + \delta R \end{aligned} \tag{6}$$

where $E(L)$ is defined as before in Model 1 as:

$$E(L) = \pi L^H + (1 - \pi)L^L. \tag{7}$$

If a good state occurs in Period 1, the license is always used as $L^H + \delta^2 R > \delta E(L_2)$. If a bad state occurs in Period 1, the license will be used if $L^L + \delta^2 R > \delta E(L_2)$, i.e., if $L^L > \delta E(L)$, or $\delta < L^L/E(L)$. If $L^L > \delta E(L)$, the license will not be used. Thus the value of a license is equal to $\max[L^L + \delta^2 R, \delta E(L_2)]$. This gives:

$$\begin{aligned} E(L_1) &= \pi(L^H + \delta^2 R) + (1 - \pi)\delta E(L_2) \\ &= E(L) + \delta^2 R + (1 - \pi)[\delta E(L) - L^L], \quad \text{if } \delta \geq \frac{L^L}{E(L)} \\ E(L_1) &= E(L) + \delta^2 R, \quad \text{if } \delta \leq \frac{L^L}{E(L)} \end{aligned} \tag{8}$$

Note that if δ is large, $E(L_1)$ contains an option value component, which is the difference between $E(L_1)$ and the best that can be obtained from choosing a given time to sell. The option value component is given by $(1 - \pi)[\delta E(L) - L^L]$; thus, it is equal to the probability of a bad

outcome in Period 1 times the gain from waiting in the event of a bad outcome. If δ is small, no option value component exists as all the licenses will be used up in Period 1 irrespective of the state.

Using the fact that $E(L_1) = R$, we can solve for R :

$$\begin{aligned} R &= \frac{[E(L)]}{1 - \delta^2} + \frac{(1 - \pi)[\delta E(L) - L^L]}{1 - \delta^2}, \text{ if } \delta \geq \frac{L^L}{E(L)} \\ R &= \frac{E(L)}{1 - \delta^2}, \text{ if } \delta \leq \frac{L^L}{E(L)} \end{aligned} \quad (9)$$

Note that R contains an option value component if δ is large. However, this is not the case if δ is small, as the new license will be used up in the first period of the next quota year. From (6) and (9):

$$\begin{aligned} E(L_2) &= \left(\frac{1 - \delta^2 + \delta}{1 - \delta^2}\right)E(L) + \frac{\delta(1 - \pi)[\delta E(L) - L^L]}{1 - \delta^2}, \text{ if } \delta \geq \frac{L^L}{E(L)} \\ E(L_2) &= \left(\frac{1 - \delta^2 + \delta}{1 - \delta^2}\right)E(L), \text{ if } \delta \leq \frac{L^L}{E(L)} \end{aligned} \quad (10)$$

If δ is large, an option value exists even in Period 2 since it enters $E(L_2)$ through the renewal value component, R !

Now consider the case where $L^L < 0$, so that $\delta > L^L/E(L)$. Consider the price for a temporary transfer of a license. It is easy to see that this could be negative! If a transfer is made

after the state is realized, say in Period 2, and it is a bad state, the price of license must be such that using it yourself is as good as selling it at price P^T . Selling it yields $P^T + \delta R$ in Period 2 and not selling it yields $L^L + \delta R$.⁶ Thus, $P^T = L^L < 0$. Note also that a permanent transfer would entail a choice between selling it for P^P and using it yourself which yields: $\max[0, L^L + \delta R]$. The price of a permanent transfer must be such that these are equal. Thus, P^P must be non-negative. Note that in addition, the difference between the price of a permanent and temporary transfer, $(P^P - P^T)$, equals δR or the present value in Period 2 of renewal rights.⁷ Thus, while temporary transfers can be associated with negative prices, permanent transfers, which are a transfer of the license and the renewal rights, cannot have negative prices.

Finally, some indication of the extent of the option value may be inferred from estimates of the interest rate and the difference in temporary and permanent transfer prices. Temporary transfers have a price of $E(L)$ on average. If there is no option value, the difference in the price of temporary and permanent transfers of licenses equals the present discounted value of future license price realizations $E(L)/(1-\delta)$. If renewal rights have an option value, X , the value of renewal rights rises, to $[E(L) + X]/(1-\delta)$. Thus:

$$P^P - P^T = \frac{[E(L) + X]}{1 - \delta} \quad \rightarrow \quad X = (P^P - P^T)(1 - \delta) - E(L). \quad (11)$$

Average license prices for temporary transfers can be used as a proxy for $E(L)$ and the discount factor can be proxied for using information on interest rates.

There are of course many problems with this approach. The implementation scheme may be quite complex and not all relevant components will be captured in such simple models. Moreover, the scarcity value of quotas is not fixed over time as assumed here. Not only are there swings over time in the use value of licenses with cyclical conditions and the entry of new supplier countries, but the quotas may be renegotiated. In fact, the MFA itself is likely to be phased out!

Model 3:

The assumption that the gain from using a license in any state is exogenously given is a very special one. Consider now a model where, for example, (small) Hong Kong exporter/license holders face a given, infinitely elastic US demand for their product. For simplicity, let their inverse export supply curve be given by the linear function:

$$P^S = \theta Q^S. \quad (12)$$

Suppose the only source of uncertainty is U.S. demand, which can be in either one of two possible states:

$$\begin{aligned} P^D &= a^H \text{ if demand is high,} \\ P^D &= a^L \text{ if demand is low,} \end{aligned} \quad (13)$$

where $a^L < a^H$. As before, the high demand state occurs with probability π , and the low demand state with probability $(1-\pi)$.

The model consists of two periods. V licenses are issued at the beginning of the first period and they are valid for two periods. We assume that the quota is binding even in the low demand period, so that $V \leq a^L/\theta$. License holders behave in a perfectly competitive manner.

Consider the second period first. Suppose there are V_2 licenses left over from the first period, where $V_2 \leq V$. All the V_2 licenses will be used since this is the last period. If the second period is a high demand period, the license price will be the difference between the high demand price in the U.S. and the price in Hong Kong when V_2 units are supplied:

$$L_2^H = a^H - \theta V_2 \quad (14)$$

and if it is a low demand period, then the license price will be:

$$L_2^L = a^L - \theta V_2. \quad (15)$$

The expected Period 2 license price is therefore:

$$\begin{aligned} E(L_2|V_2) &= \pi L_2^H + (1 - \pi)L_2^L \\ &= \pi a^H + (1 - \pi)a^L - \theta V_2 \end{aligned} \quad (16)$$

at the beginning of Period 2. Notice that the more licenses are remaining in Period 2, the lower will be the actual and expected Period 2 license price. This reflects the scarcity value of the license. This is depicted in Figure 3 -- with O_2 as the origin for V_2 , the expected value of licenses falls as V_2 increases.

Now fold the problem back to Period 1. If license holders are perfectly competitive, then the value of using the license must equal the value of not using it. Exactly enough licenses will

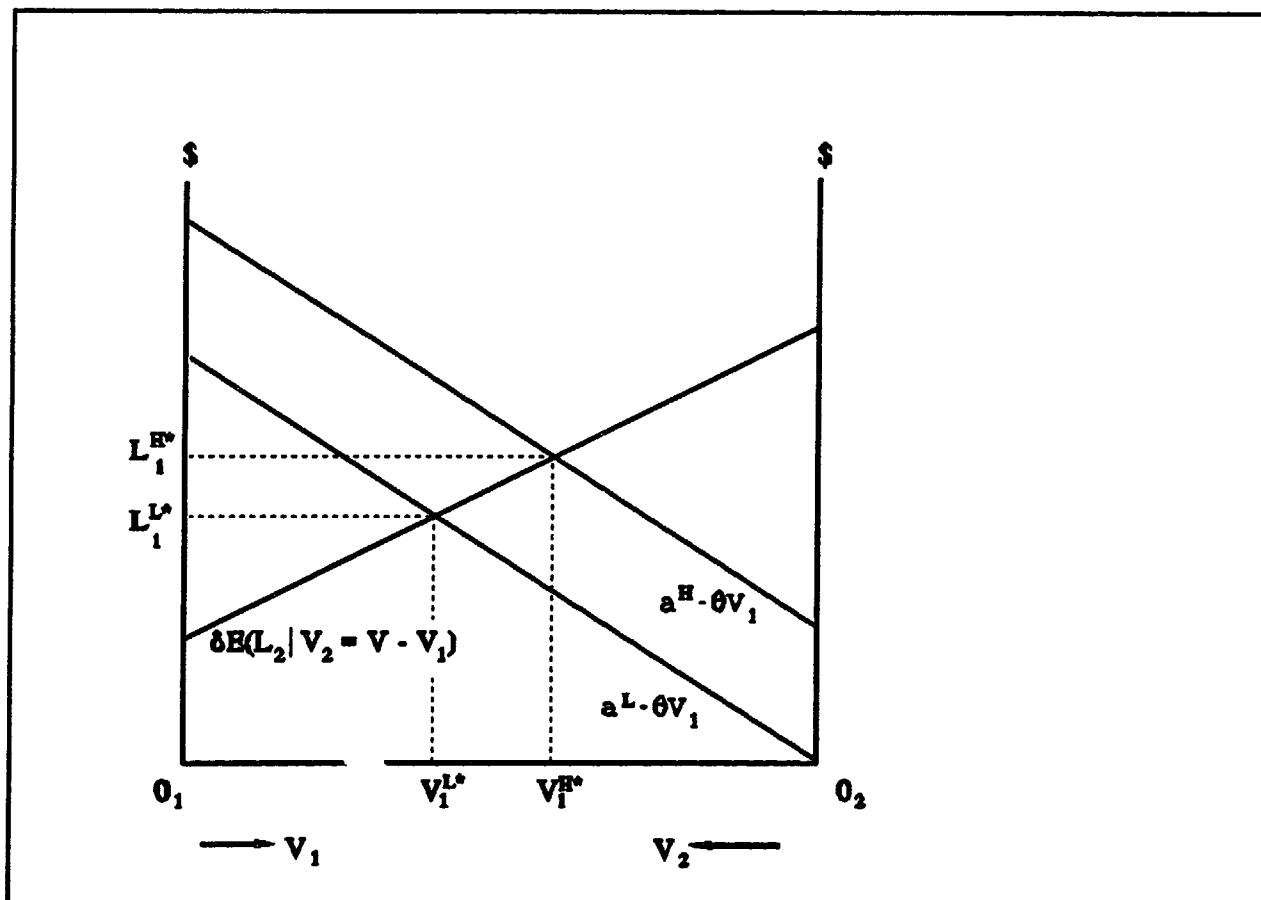
be used in Period 1 in each state so that the Period 1 license price is equal to the discounted value of the expected Period 2 license price, where the discount factor is given by $\delta = 1/(1+r)$.

In other words, V_1^H and V_1^L are chosen so as to satisfy:

$$\begin{aligned} a^H - \theta V_1^H &= \delta E(L_2 \mid V_2 = V - V_1^H) \quad \text{if Period 1 demand is high,} \\ a^L - \theta V_1^L &= \delta E(L_2 \mid V_2 = V - V_1^L) \quad \text{if Period 1 demand is low.} \end{aligned} \quad (17)$$

In Figure 3, O_1 is the origin for V_1 . The equilibrium Period 1 utilization and license price is thus

FIGURE 3: Quota Utilization in a Competitive Market



given by the intersection points in Figure 3. It is easy to solve the equations (17) for the equilibrium Period 1:

$$\begin{aligned} V_1^{H*} &= \frac{1}{\theta(1+\delta)}(a^H - \delta A + \delta \theta V) \quad \text{if Period 1 demand is high} \\ V_1^{L*} &= \frac{1}{\theta(1+\delta)}(a^L - \delta A + \delta \theta V) \quad \text{if Period 1 demand is low} \end{aligned} \quad (18)$$

and the equilibrium Period 1 license price:

$$\begin{aligned} L_1^{H*} &= \frac{\delta}{1+\delta}(a^H + A - \theta V) \quad \text{if Period 1 demand is high} \\ L_1^{L*} &= \frac{\delta}{1+\delta}(a^L + A - \theta V) \quad \text{if Period 1 demand is low} \end{aligned} \quad (19)$$

where $A = \pi a^H + (1-\pi)a^L$.

Therefore, the expected license price in Period 1 is:

$$E(L_1) = \pi L_1^{H*} + (1-\pi)L_1^{L*} \quad (20)$$

and from (17), it follows that the expected Period 2 license price at the beginning of Period 1 is simply:

Since $\delta < 1$, it is evident that $E(L_1) < E(L_2)$, that is the ex ante expected license price rises over time if the discount factor is less than one. According to this simple model, the rate of growth of the license price, $(1-\delta)/\delta$, equals the rate of interest if there is discounting. If there

$$\begin{aligned}
E(L_2) &= \pi E(L_2 | V_2 = V - V_1^{H*}) + (1 - \pi) E(L_2 | V_2 = V - V_1^{L*}) \\
&= \pi \frac{L_1^{H*}}{\delta} + (1 - \pi) \frac{L_1^{L*}}{\delta} \\
&= \frac{1}{\delta} E(L_1).
\end{aligned} \tag{21}$$

is no discounting, then the license price stays constant. In either case, the option value component of the license price is eliminated by the equilibrating mechanisms in the license market and only the scarcity and asset value components remain. This result holds even if we assume persistence of demand states.

This simple model thus suggests that the license price in any period is negatively related to the number of licenses available in that period (as evident from (14) and (15)) but that the expected license price is positively related to the time period and negatively related to the quota level (as seen from (20) and (21)). The license price is higher in good states than in bad, but in good states, license utilization is also high. Thus, we can infer license price fixing if the license price rises but license utilization falls.

Note that the option price component is missing in this model since we assume that all solutions are "interior" ones. In a model with many possible states, some of which lead to corner solutions (for example, if some states exist where even if all existing licenses are used, it is strictly preferable to use a license rather than hold on to it) the option value component will re-emerge as there will be a gap between the value of using and not using a license. This option price component could result in license prices falling over time.

Model 4:

Finally, let us consider the implications of imperfect competition in the license market. This is made complex by the fact that most quota implementation procedures encourage license holders to fill their allotted quota. Given this aspect of the implementation procedure, imperfect competition in the license market cannot restrict the supply of licenses over the entire period. However, it can certainly affect the chosen path of license utilization relative to the path which would obtain in the case of perfect competition. Thus it can affect the path of license prices as well.

This point can be shown quite starkly with a slight modification of the previous model. Suppose we retain the previous assumption that there are competitive suppliers of the restricted product, with the supply price given by $P^s = \Theta Q^s$ as in equation (12); and that the U.S. demand price is either a^H (high) or a^L (low) as in equation (13). However, now suppose there is only one license holder who obtains the product from the competitive suppliers and sells it in the quota-constrained U.S. market.

In Model 3, with perfectly competitive license holders, the expected license price in Period 1 is given by equating the value of using the license in that state with the discounted value of holding on to the license for use in the next period, i.e.:

$$a^{s1} - \theta V_1^{s1} = \delta E(L_2 | V - V_1^{s1}) \quad (22)$$

where $s1$ denotes the state of demand in Period 1, $s1 = H$ or L . The left hand side of the equation, $(a^{s1} - \theta V_1^{s1})$, is a negative function of V_1^{s1} whilst the right hand side, $\delta E(L_2 | V - V_1^{s1})$, is a positive function of V_1^{s1} (i.e., a negative function of V_2). In Figure 4, their intersection at

C^H determines the equilibrium utilization and price (V_1^{HC} , L_1^{HC}) if Period 1 is a high demand state, and their intersection at C^L determines the equilibrium (V_1^{LC} , L_1^{LC}) if Period 1 is a low demand state.

Now consider the case of a monopolist license holder who realizes that using more licenses (i.e., exporting more of the quota-constrained product) will raise the supply price of the product. Whereas in the competitive case the equilibrium Period 1 license utilization and price were found by equating the average revenue from using the licenses with the average revenue from holding them for the next period, the relevant consideration for the monopolist license holder is instead the marginal revenue from using the licenses in Period 1 versus the marginal revenue from holding on to them. Now, in Period 1, given the state of demand s_1 , the marginal revenue from using the licenses is:

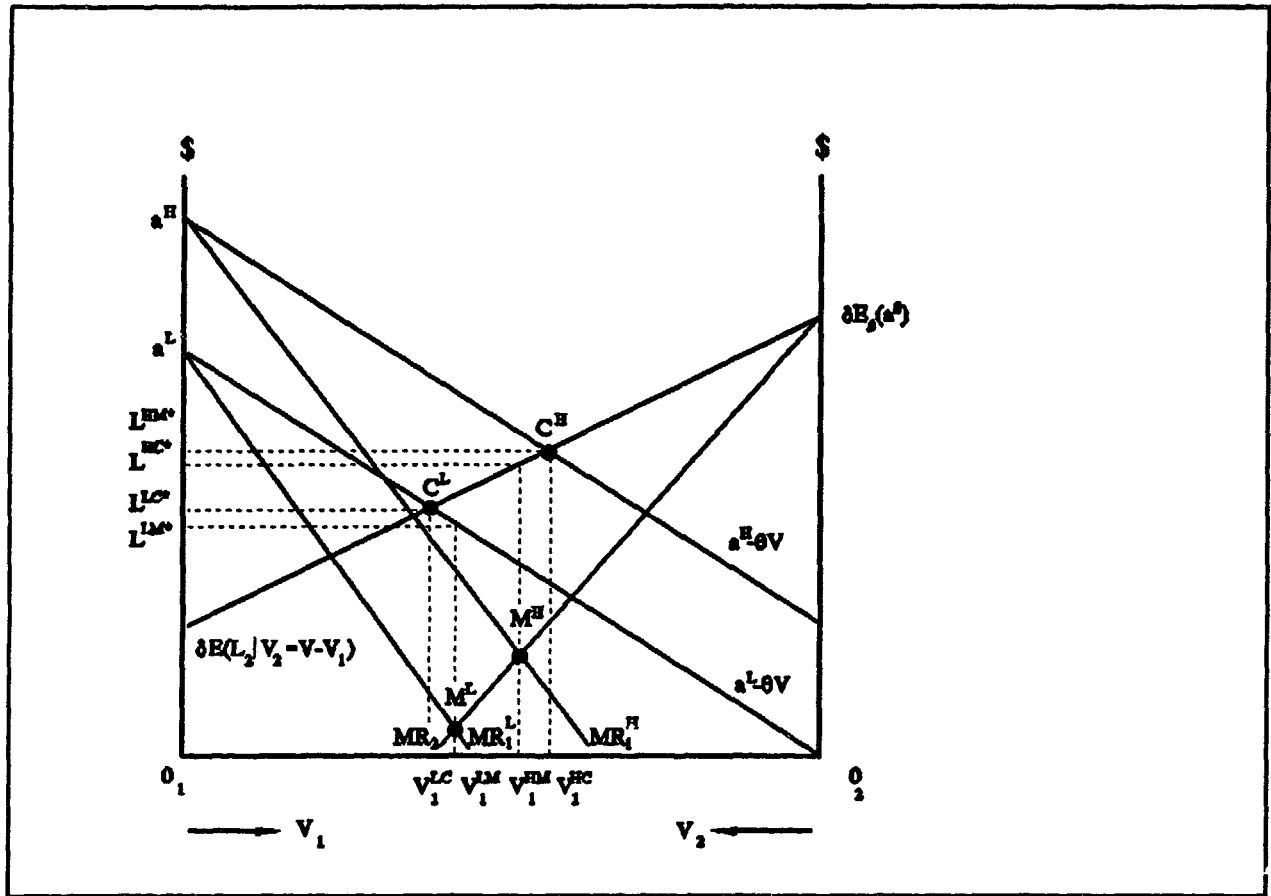
$$MR_1^{s_1} = a^{s_1} - 2\theta V_1^{s_1} \quad (23)$$

and the marginal revenue from holding the licenses (i.e., using them in Period 2) is:

$$MR_2 = \delta \{E_{s_2}[a^{s_2}] - 2\theta V_2\} \quad (24)$$

where s_2 denotes the state of demand in Period 2, $s_2 = H$ or L . The license holder will choose the Period 1 utilization so as to maintain indifference between the two choices of action. In Figure 4, the intersection M^H denotes the equilibrium if Period 1 is a high demand state, and M^L denotes the equilibrium if Period 1 is a low demand state. The corresponding license utilizations and prices are (V_1^{HM} , L_1^{HM}) if Period 1 is a high demand state, and (V_1^{LM} , L_1^{LM}) if Period 1 is a low demand state.

FIGURE 4: Quota Utilization by a Monopolist



The exact location of the equilibrium points for the monopolist relative to the competitive situation depends of course on factors such as the discount rate, the relative demand prices in the two states and the probability of occurrence of the states. Our main point is simply that the utilization and price paths of the quota licenses are quite different with imperfect competition than they are under perfect competition, even though the total utilization is the same in both cases.

I.3. Some Related Work

That quota licenses can be viewed as options is not a new insight. For example, Anderson (1987) likens a quota license to an American-type put option, although he notes that the endogeneity of license prices in any period makes the analogy with the option pricing literature suspect. He shows that in a world of uncertainty licenses can have a positive price ex-ante, even when the quota is unfilled in some states. He also considers the use-it-or-lose-it requirement, where license holders are penalized for unfilled quotas by smaller allocations in the next period. He points out that in this case license prices could be negative, since license holders have an incentive to use their licenses in the current period, even at a loss, so as to be assured of future allocations.

Eldor and Marcus (1988) extend Anderson's analysis, drawing upon the financial literature to obtain an explicit formula for the value of a quota license in a stochastic environment. However, we argue below that their assumptions result in their model neglecting a fundamental force which drives the market and which needs to be understood. The following discussion uses the same model found in their paper, with the same notation for ease of reference.

Let p^* be the world price (and the price in the exporting country) where p^* is a random variable. Let p_{eq} be the price in the quota-restricted country. This is endogenously determined by demand and supply conditions. The difference between these two prices creates the scarcity value of a license.

Since the license holder always has the option of not using the license, the license holder can get a payoff of $\max[p_{eq} - p^*, 0]$. If p_{eq} is a constant, then as p^* is a random variable, the license becomes exactly like a put option which gives the holder the right to sell a unit of stock at the price p_{eq} when the random market price is p^* . A clever trick in Eldor and Marcus shows that this analogy can be exploited under certain assumptions.

Consider the value of a license which can be exercised only at the end of the whole period, e.g., at time T . Let p_M denote the equilibrium price in the quota-restricted market if imports are exactly equal to the quota level. Assume (as do Eldor and Marcus) that the demand and supply functions in the importing country are non stochastic. This makes p_M a function of the quota level alone. Let p^* denote the price in the importing country for zero imports, i.e., autarky. Of course, $p_a > p_M$. Now note that there are only three possibilities, which can be summarized by cases (a), (b), and (c) below:

(a) $p^* > p_a > p_M$:

$$p_{eq} = p_a, \text{ and gives } \max[p_{eq} - p^*, 0] = \max[p_M - p^*, 0]$$

(b) $p_a \geq p^* \geq p_M$:

$$p_{eq} = p^*, \text{ and gives } \max[p_{eq} - p^*, 0] = \max[p_M - p^*, 0]$$

(c) $p_a > p_M > p^*$:

$$p_{eq} = p_M, \text{ and gives } \max[p_{eq} - p^*, 0] = \max[p_M - p^*, 0]$$

The three cases are illustrated in Figure 5. In case (a) the equilibrium price is the autarky price. However, as the autarky price is less than the world price, the value of holding a license

is zero. Since p_M is even lower than the autarky price, the value of a license also equals the maximum of $(p_M - p^*)$ and zero. In case (b), the equilibrium price is the world price so that the value of a license is exactly zero. Since p_M is less than p^* , again this license value equals the maximum of $(p_M - p^*)$ and zero. In case (c) the equilibrium price is p_M so that the license price is positive and again equals the maximum of $(p_M - p^*)$ and zero.

This is the clever trick used in the Eldor-Marcus paper. Although p_{eq} is an endogenous variable and depends on the realization of p^* , the value of a license can be expressed as a function of p_M and p^* alone in each state. Since p_M depends only on the number of licenses available, it is a constant. This makes the license resemble a European-style put option.

However, in practice, licenses may be exercised at any time during the quota period. In extending their model to allow for this, Eldor and Marcus assume that as licenses are used up over a year, they are replenished to the set quota level. This assumption ensures the P_M does not vary over the year and makes the problem exactly like that of valuing an American-style put option!

However, this assumption is inappropriate for a number of reasons. First a key factor determining the time path of licenses over the quota period is the relationship between future prices and current prices through the effect of current use on future availability. Second, incorporating the effect of current use on future availability and prices shows that the option price component is much less important than it seems. In fact, under plausible circumstances as in Model 3, it may not even exist! When it does exist, of course, this option value falls as the

The figure consists of three separate supply and demand graphs, each with a vertical price axis and a horizontal quantity axis labeled Q . All three graphs share a common downward-sloping demand curve labeled D .

- Graph 1 (Left):** Shows a perfectly elastic supply curve S_1 (horizontal) and a perfectly elastic supply curve S' (horizontal) at a higher price level. The initial equilibrium is at the intersection of S_1 and D , corresponding to price P_u . The new equilibrium, after the supply shift to S' , is at the intersection of S' and D , corresponding to price P'_u .
- Graph 2 (Middle):** Shows a perfectly elastic supply curve S_1 (horizontal) and a perfectly elastic supply curve S (horizontal) at a higher price level. The initial equilibrium is at the intersection of S_1 and D , corresponding to price P_u . The new equilibrium, after the supply shift to S , is at the intersection of S and D , corresponding to price P'_u .
- Graph 3 (Right):** Shows a perfectly elastic supply curve S_1 (horizontal) and a perfectly elastic supply curve S (horizontal) at a higher price level. The initial equilibrium is at the intersection of S_1 and D , corresponding to price P_u . The new equilibrium, after the supply shift to S , is at the intersection of S and D , corresponding to price P'_u .

24

I.4. Conclusion

In this paper we studied the determinants of the price path of a quota license over its validity period. We argued that the dynamic aspects of the problem in an uncertain environment, together with the usual policy of rewarding high license utilization with future license allocations, creates four components of the license price. These are the scarcity, option value, asset market, and renewal value components. By contrast, static models have only the scarcity value. We showed that the renewal value component also has an option value element and suggested ways of getting a handle on the option value component.

We also showed that the usual treatment of the option value component as in the work of Eldor and Marcus (1988) neglects an essential part of the problem. Eldor and Marcus claim that they solve the problems posed by the endogeneity of the license price. However, they do this by assuming that there is a constant number of licenses at all times because licenses are continuously replenished as they are exercised, although the new licenses are not necessarily issued to the current license holders. This assumption is critical to their results since it makes the license price in the future independent of the number of licenses used today. If the number of licenses in the next period is allowed to vary, the price realizations in the next period will also vary. This endogeneity in price is what equates the value of current exercise and holding the asset until further information is revealed, and this eliminates the option price component for interior solutions. Neither Anderson nor Eldor and Marcus test their models empirically with real world data as we do in the companion paper.

II. APPAREL QUOTA LICENSE PRICE PATHS: EVIDENCE FROM HONG KONG²

II.1. Introduction

The MFA, or Multi-Fibre Arrangement, is among the most important non-tariff trade barriers facing developing countries today. It sanctions a structure of country- and product-specific quotas on apparel and textiles exported by developing countries to developed countries.

The MFA has been widely studied and much attention has been devoted to its welfare consequences.⁸ For example, Morkre (1984) estimates that U.S. clothing import quotas on Hong Kong in 1980 gave rise to quota rents of \$218 million, or 23 per cent of the total value of clothing imports from Hong Kong; Hamilton (1986) calculates the import tariff equivalent rate of textile and apparel quotas on Hong Kong to be 9 per cent in 1981 and 37 per cent in 1982; and Trela and Whalley (1988, 1991) suggest global gains from the elimination of quotas and tariffs of more than \$17 billion (of which \$11 billion will accrue to developing countries) and gains to the U.S. from the removal of quotas of \$3 billion.

These estimates are based on static models which assume perfect competition in all relevant markets. In such models, as is well known, tariffs and quotas are equivalent and license prices, when available, reflect the scarcity induced by the quotas and equal the implicit specific

² We are grateful to the World Bank for research support. We would also like to thank Ronald Chan, Carl Hamilton, P.C. Leung, Peter Ngan and Yun-Wing Sung for providing us with data, and Carlos Ramírez for useful discussions.

tariff. The usual practice in these empirical studies is to take the quota license price as a measure of the wedge between import price and unit cost in the exporting country and to take the ad-valorem tariff equivalent as a measure of restrictiveness of the quota.⁹

In dynamic settings, the license price has two additional components, both of which are related to the property that a license is valid for an entire year. The first of these is the asset market component. A quota license can be viewed as an asset with a life of one year. Like any other asset, the price path of the license must be such that it is held voluntarily. For this to occur in a world without uncertainty, the price of the asset must rise at the rate of interest, as the latter represents the opportunity cost of holding the asset. Therefore, the asset market component predicts that the price of a license will rise over the year.

The second additional component of the license price is the option value component. At any point in time during the year, a quota holder can either use the license (by shipping the goods or by making a temporary transfer to someone else) or defer the license application in the hope of a higher price in the future if demand realizations are high. The value of a license held today, before the state tomorrow is known, can exceed the expected price of the license at any time in the future since a license allows the decision on use to be deferred until the state is known. In other words, a quota license has an "option" value.

In addition, the details of the quota allocation mechanism can create other complications which affect the license price. For example, quota allocations may be tied to past performance,

as is the case in Hong Kong and most other exporting countries, where firms with a high quota utilization are rewarded with an increased allocation in the next period. This creates a renewal value component of the license price. These components of the license price are studied in the companion theoretical paper. Earlier theoretical work on this area includes that of Anderson (1987) and Eldor and Marcus (1988). However, to our knowledge, there is no empirical work on license price paths.

The case of Hong Kong is the most frequently studied, one reason being that Hong Kong quota prices are relatively easy to obtain since their quota licenses are traded on the open market. In studying other exporting countries, where quota prices are harder to come by, researchers often use Hong Kong quota prices as proxies.¹⁰ Moreover, even when weekly or monthly license price data are available, the usual procedure is to average the license prices over the year since complementary data are usually available only annually. This is the approach used in Morkre (1984), Hamilton (1986) and Trela and Whalley (1988), for example.

There are two problems with doing this. First, as licenses are valid for an entire year, and there is uncertainty, the simple static model is not quite adequate. In such an environment, license prices have a number of components as indicated above, not just the scarcity component of the standard static model. Thus, it is not clear exactly what the average license price represents! Second, this averaging procedure effectively discards a huge amount of economically relevant information which can be used to shed light on other interesting questions.

In this paper we study the dynamic behavior of license prices in a competitive market. We then test for deviations from this paradigm. We base our empirical study on Hong Kong data. Our choice is pragmatic because of the availability of data on licenses for Hong Kong. In addition, licenses are relatively freely traded in Hong Kong compared to other MFA-restricted countries, and the quota implementation process is clearly documented. As a result, it is the least likely to exhibit behavior consistent with market imperfections.

Even so, allegations of license price-rigging in Hong Kong are made from time to time in the textile trade journals, although the evidence put forth to support these claims is not always convincing. For example, editorials in the trade journal, Textile Asia, claim that "... the availability of quota at the beginning of the year is limited by the operations of holders determined to wait till what seems the best possible price is attained,"¹¹ and as a result, "quota price fluctuations do not in fact reflect normal supply and demand but the course of manipulation by the quota holders."¹² Note that the first of the two quotes is not inconsistent with perfect competition in an uncertain environment, and the second is merely an assertion. Other assertions of price fixing point to high license prices as evidence. However, this could be a reflection of competitive responses to market conditions, such as high demand realizations, and not price fixing. We provide the first attempt to test such claims in a coherent manner.

The paper is organized as follows. Section 2 sets out a simple demand and supply model which provides the basis for the econometric model used. Section 3 outlines the details of Hong Kong's textile quota system. Section 4 discusses the data we use. Section 5 estimates the model

developed and looks at whether there is evidence of market power in the license market. Section 6 summarizes our results and makes some concluding remarks.

II.2. Developing a Testable Model

It is apparent from the discussion in the companion paper that license price paths are a complicated phenomenon to model, and simply observing these time paths will not enable us to draw any conclusions about the existence of imperfect competition in the license market. In this section, we develop the model on which our econometric work will be based. As far as possible, we try to capture all the theoretical considerations raised in the companion paper. There are T time periods, indexed by $t = 1, \dots, T$, in a quota year. In each time period, there is a demand for and supply of licenses as a function of their price. The demand for licenses is straightforward. It is based on the excess demand for apparel in the importing country; i.e., demand in the importing country less supply from all other sources.

This is denoted by:

$$D_{it} = D \overset{(-)}{(L_{it}}, \overset{(-)}{H_{it}}, \overset{(-)}{C_{it}^{HK}}, \overset{(+)}{R_{it}}) \quad (25)$$

where:

- L_{it} = License price of category i at time t .
- C_{it}^{HK} = Cost of production in Hong Kong for category i at time t .
- R_{it} = An index of retail sales in the U.S.
- H_{it} = The numbers equivalent of the Herfindahl index of concentration.

The expected signs of the partial derivatives are indicated above the variables and explained below. Demand depends on the full price of the good produced in Hong Kong. The full price includes the price in Hong Kong, the license price, and any search costs involved in obtaining a license. The Hong Kong price is positively related to the cost of production in Hong Kong, so that as the cost of production rises in Hong Kong, demand for licenses falls. As this full price is inclusive of the license price, increases in the license price also reduce demand. The numbers equivalent of the Herfindahl index is a proxy for the number of equal sized firms that own licenses. Thus, it provides an indication of the extent of concentration in license holdings. Demand would fall with a decrease in concentration (i.e., an increase in the numbers equivalent) if this leads to higher search costs, which have to be included in the true cost of doing business.¹³

Now consider the supply side. At each point in time, a license holder must decide whether to use the license or hold on to it for another period. The supply of licenses in category i at time t is given by:

$$S_{it} = S(L_{it}^{(+)} \frac{A_{it}^{(+)}}{(T-t)}, t, C_{it}^{HK(?)}) \quad (26)$$

A_{it} is the total availability of licenses at time t in category i . As before, C_{it}^{HK} denotes costs in the exporting country, Hong Kong.

As usual, $S_{it}(\cdot)$ increases with the current license price, L_{it} . Supply also rises as $A_{it}/(T-t)$ rises; this is because an increased availability of licenses relative to the amount of time

remaining lowers their expected price in the future, and this in turn lowers the value of holding on to a license. The supply of licenses should also rise with the Hong Kong cost of production, given a license price, as this reduces the value of holding on to a license. Finally, other things constant, supply may also depend on the time period, t , itself: the option value argument predicts that supply will be larger in later months when there is less of an option value in holding on to a license; on the other hand, asset price arguments predict the opposite, as in later months, higher license prices will be required to elicit the same supply as license holders must be compensated for interest forgone in holding a license.¹⁴

In a competitive setting, H_t should not affect supply. If the license market is not competitive, it is not obvious that greater concentration would reduce the entire supply path, as the past performance rule in the quota allocation mechanism encourages full utilization of licenses. However, it could certainly affect the path of quota utilization over the year and thereby raise license prices. This is discussed further below.

In equilibrium, demand equals supply:

$$D_u(\cdot) = S_u(\cdot) = U_u \quad (27)$$

The equilibrium level of quota utilization is denoted by U_t . Both U_t and L_t are observed monthly. Equations (1)-(3) make up the structural form of the simultaneous equations model. The endogenous variables of the system are demand (D_t), supply (S_t) and the license price (L_t).

We will first estimate the reduced form of the system. It is easy to verify that the reduced form of the simultaneous equation system allows us to solve for the license price and quota

utilization in any period as a function of the exogenous variables in the model. This gives:

$$L_u(C_u^{HK}, H_u, R_u, \frac{A_u}{(T-t)}, t) \quad \begin{matrix} (-) & (-) & (+) & (-) & (?) \end{matrix} \quad (28)$$

$$U_u(C_u^{HK}, H_u, R_u, \frac{A_u}{(T-t)}, t) \quad \begin{matrix} (?) & (-) & (+) & (+) & (?) \end{matrix} \quad (29)$$

An increase in the U.S. retail sales index, R_u , shifts $D_u(\cdot)$ out, raising the equilibrium license price, $L_u(\cdot)$, and quota utilization, $U_u(\cdot)$. If search costs are substantial, then an increase in H_u will shift $D_u(\cdot)$ in, so that $L_u(\cdot)$ and $U_u(\cdot)$ fall in equilibrium. An increase in C_u^{HK} will shift the supply for licenses outward and the demand for licenses inward. This will lower $L_u(\cdot)$ and can raise or lower $U_u(\cdot)$. It raises $U_u(\cdot)$ if the supply shift effect dominates, and reduces $U_u(\cdot)$ if the demand shift effect dominates. An increase in $A_u/(T-t)$ shifts $S_u(\cdot)$ outward, reducing $L_u(\cdot)$ and raising $U_u(\cdot)$.

The effect of an increase in t is ambiguous. However, it should have opposite effects on prices and quantities. This model provides the motivation for the reduced form and structural equations we run in Section 5. In the next two sections, we describe the workings of the Hong Kong quota system and the data we use.

3. Hong Kong's Textile Quota System

Hong Kong prides itself on administering an efficient textile quota system. The initial quota allocation is historically based. Past performance, transfers and quota level changes guide the process by which these allocations change in subsequent years.

When a product category is newly brought under restraint, the quotas are allocated according to past performance,¹⁵ i.e., each company gets a quota amount corresponding to its share in total shipments of that particular category to the market concerned. Where the manufacturer and the exporter are not the same company, they each share the quota pertaining to a shipment on a 50/50 basis.¹⁶ If the level of total shipments exceeds the restraint limit, the allocations are scaled down proportionately. If the quota is more generous than total past performance, then the balance remaining is put into a "free quota pool", which is open to any firm registered with the Hong Kong Trade Department and which has documentary proof of an overseas order.

Quota holders are allowed to transfer a part of their quota to other firms. There are two types of quota transfers: permanent transfers, in which the transferee obtains the use of the quota for the year in question and, based on its performance against the transferred amount, receives a quota allocation in the following year; and temporary transfers, in which the transferee obtains the use of the quota for the year in question, but the performance against the transferred quantity is attributed to the transferor. In order to allow sufficient time for the transferee to obtain the quota, transfer applications are not normally accepted after the middle of November. Free quotas are not transferable.

Under Hong Kong's textile quota system, both the utilization rate and the amount of transfers are important factors in determining a firm's future quota allocation. A firm which uses less than 95 per cent of its quota holding will obtain an allocation in the subsequent year equal to the amount it used; a firm which uses 95 per cent or more of its quota holding will be given an allocation equal to 100 per cent of its holding; and a firm which uses 95 per cent or more of its quota holding and does not transfer out any of its quota (on either a temporary or permanent basis) will be awarded an additional amount equivalent to the growth factor for that category provided for in the restraint agreement.

In addition, a firm which transfers out 50 per cent or more of its quota holdings on a temporary basis in a year is liable to have its quota allocation reduced in the following year,¹⁷ whereas a firm which transfers in 35 per cent or more of its quota holdings on a temporary basis during the year is eligible for a bonus allocation in the following year.

Finally, a firm which obtains a free quota and utilizes 95 per cent or more of it qualifies for a quota allocation in the subsequent year; a firm which fails to utilize at least 95 per cent of its free quota may be debarred from future participation in free quota schemes for a period of time.

To a certain extent, unused quotas may be transferred between categories (under the "swing provision") and between years (under the "carry-over" and "carry-forward provisions").

As quota entitlements in a subsequent restraint period are based on shipment performance in the preceding period, quotas can only be allocated after this performance has been fully verified against shipping documents. This verification process usually takes two to three months. In order to make a portion of the quotas available during the first few months of the year, therefore, the Trade Department makes preliminary quota allocations to companies. Final quota allocations are normally made in March and they supersede any preliminary allocations.

All textile and apparel exports from Hong Kong have to be covered by valid export licenses issued by the Director of Trade. Export licenses are only issued to firms which are able to supply quota to cover the consignment in question. Valid licenses are required to bring the shipment on board. An export license is normally valid for 28 days from the date of issue (or, where applicable, until the end of the year, whichever is earlier). The consignment must be shipped within this period. The final licensing date is the first day of December. All licenses covering shipments applied for against quotas held by a company have to be taken out not later than this date, although shipments may be effected up to the last day of the year.

Further details of Hong Kong's textile quota system can be found in the Hong Kong Trade Department publication, Textiles Export Control System. A good description of the system is also contained in Morkre (1979, 1984).

II.4. The Data

The data utilized in this study cover the time period 1982-88. They are classified according to MFA categories. Since the quota licenses are MFA category specific, we have no aggregation problems. We do not have information on all categories for the entire period. However, we believe our data are the best available and that they suffice for our purposes.

As described in the previous section, quota licenses in Hong Kong are transferable to a certain extent. However, there is no systematic record of the transactions and we owe a great deal to Carl Hamilton at the University of Stockholm's Institute for International Economic Studies and Peter Ngan of the Federation of Hong Kong Garment Manufacturers, who provided us with monthly license prices for many MFA categories. Additional information was obtained from Textile Asia, which frequently tracks quota license prices. The license prices (L_{it}) are prices for temporary transfers and are expressed in Hong Kong dollars per dozen pieces. They are monthly averages unless otherwise stated.

Aside from monthly license prices, we also collected data on monthly quota utilization, cumulative (year-to-date) quota utilization and annual quota levels by MFA category. These figures are published monthly in the Notice to Exporters Series 1A (USA) documented by the Trade Industry and Customs Department of Hong Kong. The quota level (V_{it}), monthly quota utilization (U_{it}) and cumulative quota utilization (ΣU_{it}) are expressed in dozens of pieces. From these, we calculated the availability of licenses for the rest of the year, A_{it} , as:

$$A_{it} = V_{it} - \sum_{i=1}^{t-1} U_{it} \quad (30)$$

Monthly Hong Kong costs (C_{it}^{HK}) were proxied by monthly wage rates in Hong Kong's apparel sector. These were approximated as the total monthly payroll in that sector divided by the number of persons engaged, using data published in the Hong Kong Monthly Digest of Statistics. The state of demand in the U.S. was proxied by an index of retail sales, R_{it} .

We obtained information on the license allocation in Hong Kong for the years 1982 and 1986 through 1988 from the Quota Holders' List issued by the Textile Controls Registry in Hong Kong. We computed the numbers equivalent of the Herfindahl index of concentration in license holding (H_{it}) for each MFA category using these license allocation data.¹⁸ The numbers equivalent is inversely related to the degree of concentration. Finally, $(T-t)$ was taken as the number of months remaining in the year.

II.5. Testing for License Market Imperfections

Our first approach to testing for license market imperfections is to use regression analysis to estimate the reduced form equations developed in Section 3. We ran the following log-linear model to capture the competitive model developed above:¹⁹

$$\begin{aligned}
\log(L_{it}) &= \beta_0 + \beta_1 \frac{A_{it}}{V_{it}(T-t)} + \beta_2(T-t) + \beta_3(T-t)^2 + \beta_4 R_{it} + \beta_5 H_{it} + \beta_6 H_{it}(T-t) + \beta_7 C_{it}^{HK} \\
&\quad + \sum_{j=1}^{21} \mu_j D_j + \sum_{k=1}^6 \theta_k Y_k + \epsilon_{it} \\
\log(U_{it}) &= \beta'_0 + \beta'_1 \frac{A_{it}}{V_{it}(T-t)} + \beta'_2(T-t) + \beta'_3(T-t)^2 + \beta'_4 R_{it} + \beta'_5 H_{it} + \beta'_6 H_{it}(T-t) + \beta'_7 C_{it}^{HK} \\
&\quad + \sum_{j=1}^{21} \mu'_j D_j + \sum_{k=1}^6 \theta'_k Y_k + \epsilon'_{it}
\end{aligned} \tag{31}$$

The data were pooled across time and categories, seven years and 22 categories in all. In the above equations, the subscript i represents the MFA category and the subscript t represents the month in which the observation was made, where $t=1, \dots, 12$. The variable $(T-t)$ therefore denotes the amount of time remaining from the beginning of month t for which the license can be used, and is computed simply as $(13-t)$. Note that the log-linear specification enables β_2 to be interpreted as the rate of change of the license price. We took into consideration the fact that the quota utilization and license price paths over time may not be linear by including as well the quadratic term, $(T-t)^2$, as an explanatory variable.

The variable $H_{it}(T-t)$ is an interaction term to capture the effect of the concentration in license holdings as a function of time. This term was introduced to take into account the possibility raised in Section 3 that in the absence of perfect competition, concentration in license holdings could affect the time path of quota utilization. Clearly, if the license market were

competitive, H_{it} should have no effect on the supply of licenses. But even in the case of imperfect competition, the past performance rule in the quota allocation mechanism should ensure that H_{it} would not affect the entire supply path of licenses; since license holders are penalized for under-utilization with reduced allocations in the following year, they would have no incentive to restrict the supply of licenses for the entire year in the hopes of driving up the license price. However, as discussed in the companion paper, imperfect competition in the license market would result in license price and utilization paths quite different from the competitive case. The (percentage) effect of license holding concentration on the equilibrium utilization at time t is thus given in Equation (7) as $\beta_5' + \beta_6'(T-t)$.

We also scaled the variable $A_{it}/(T-t)$ by the quota level, V_{it} , rendering it unit-free. This was done in order to maintain comparability between categories in the pooled data set. This variable captures the scarcity component of the license price. Finally, we included category dummies, D_j , $j=1,\dots,21$, to permit different levels of license prices and quota utilization across categories, and year dummies, Y_k , $k=1,\dots,6$, to allow for annual variations.

The results of the OLS estimation of the reduced form equations are given in Tables 1(a) and 1(b). Also included in the tables are the expected signs of the coefficients on the independent variables which follow from equations (4) and (5) in Section 2.

As predicted, an increase in availability always reduces the equilibrium license price and increases the equilibrium quantity utilized at any time t ; and an increase in retail sales in the

TABLE 1(a): ESTIMATE OF REDUCED FORM REGRESSION (7), UTILIZATION EQUATION

Dependent variable = $\log(U_{it})$

Independent Variable	Coefficient	t Statistic	Expected sign of coefficient*
Constant	5.9076 (1.6696)	3.5383 ^a	
C_{it}^{HK}	0.0011 (0.0001)	9.3284 ^a	(?)
R_{it}	0.0126 (0.0173)	0.7280	(+)
$A_{it}/[V_{it}(T-t)]$	5.3299 (0.9112)	5.8489 ^a	(+)
$T-t$	0.5054 (0.0465)	10.8771 ^a	(?)
$(T-t)^2$	-0.0382 (0.0029)	-13.0172 ^a	(?)
H_{it}	0.0001 (0.0066)	0.0189	(-)
$H_{it}(T-t)$	0.0007 (0.0005)	1.3537 ^d	(0)

$R^2 = 0.8588$

Adjusted $R^2 = 0.8511$

21 category dummies and 6 year dummies included.

Number of observations = 662

Standard errors in parentheses.

*From Equation (5) for a competitive model.

^a: Significant at the 1 per cent level.

^b: Significant at the 5 per cent level.

^c: Significant at the 10 per cent level.

^d: Significant at the 20 per cent level.

TABLE 1(b)
ESTIMATE OF REDUCED FORM REGRESSION (7), LICENSE PRICE EQUATION

Dependent variable = $\log(L_{it})$

Independent Variable	Coefficient	t Statistic	Expected sign of coefficient*
Constant	-6.3502 (1.9130)	-3.3195 ^a	
C_{it}^{HK}	-0.0004 (0.0001)	-3.0574 ^a	(-)
R_{it}	0.1143 (0.0198)	5.7585 ^a	(+)
$A_{it}/[V_{it}(T-t)]$	-6.8906 (1.0441)	-6.5994 ^a	(-)
$T-t$	-0.0574 (0.0532)	-1.0788	(?)
$(T-t)^2$	0.0123 (0.0034)	3.6480 ^a	(?)
H_{it}	0.0014 (0.0076)	0.1848	(-)
$H_{it}(T-t)$	-0.0011 (0.0006)	-1.7822 ^c	(0)

$R^2 = 0.7720$

Adjusted $R^2 = 0.7596$

21 category dummies and 6 year dummies included.

Number of observations = 662

Standard errors in parentheses.

*From Equation (4) for a competitive model.

^a: Significant at the 1 per cent level.

^b: Significant at the 5 per cent level.

^c: Significant at the 10 per cent level.

^d: Significant at the 20 per cent level.

U.S. tends to increase both the equilibrium license price and the equilibrium quota utilization at time t . An increase in Hong Kong costs (as proxied by the wage per worker in the apparel sector) lowers the equilibrium license price as expected, and raises the equilibrium quota utilization -- this suggests that its effect on the supply of licenses outweighs its effect on the demand for licenses.

The time path of the equilibrium quota utilization is quadratic, with the utilization increasing (at a decreasing rate) from January until the middle of the year, after which it starts to fall. Note from equation (7) and Table 1(a) that:

$$\begin{aligned}\frac{\partial U_t / U_t}{\partial t} &= -\beta'_2 - 2\beta'_3(T - t) - \beta'_6 H_t \\ &= -0.5054 + 0.0764(T - t) - 0.0007 H_t\end{aligned}\tag{32}$$

where $t=1$ (and $T-t=12$) in January, $t=2$ (and $T-t=11$) in February, and so on, and H_t ranges from 12 to 65. The time path of the equilibrium license price is also quadratic but in the opposite direction, with the license price decreasing from January until the last quarter of the year before it starts to increase. Again, from equation (7) and Table 1(b), we have:

$$\begin{aligned}\frac{\partial L_t / L_t}{\partial t} &= -\beta_2 - 2\beta_3(T - t) - \beta_6 H_t \\ &= 0.0574 - 0.0246(T - t) + 0.0011 H_t\end{aligned}\tag{33}$$

As discussed in the companion paper, the asset market component predicts that the license price

will rise over time, whereas the option value component predicts that the license price will fall over the course of the year. Equation (9) shows that with the scarcity component controlled for, the license price path indeed reflects the influence of the option value component in the beginning of the year, with the asset market component coming into play towards the end of the year.

The numbers equivalent is not significantly different from zero in both equations, indicating that search costs are not too important. Interestingly, however, the interaction term, $H_h(T-t)$, is significantly positive in the utilization equation and significantly negative in the license price equation. This means that an increase in license holding concentration decreases the slope of the license price path, making it fall more steeply and rise more gradually than the competitive path.²⁰ Conversely, an increase in license holding concentration increases the slope of the license utilization path, making it rise more steeply and fall more gradually than the competitive path.²¹ This indicates that the equilibrium license price and quota utilization paths are indeed affected by the concentration in license holdings -- a result which is strongly suggestive of imperfect competition in the license market.

The reduced form estimates, therefore, suggest that the competitive model's implications are not quite borne out. In order to provide a further check, we estimate the structural equations using two stage least squares. It is easy to confirm that using exclusion restrictions alone permits identification of our simultaneous equations system although the structural equations are overidentified. If the interaction term enters the supply function in a significant manner, we have some evidence of imperfections in the market.

The structural form equations we estimated were:

$$\begin{aligned}\log(D_{it}) &= \alpha_0 + \alpha_1 \log(L_{it}) + \alpha_2 C_{it}^{HK} + \alpha_3 R_{it} + \alpha_4 H_{it} + \sum_{j=1}^{21} \mu_j D_j + \sum_{k=1}^6 \theta_k Y_k + \epsilon_{it} \\ \log(S_{it}) &= \alpha'_0 + \alpha'_1 \log(L_{it}) + \alpha'_2 C_{it}^{HK} + \alpha'_3 \frac{A_{it}}{V_{it}(T-t)} + \alpha'_4 (T-t) + \alpha'_5 (T-t)^2 + \alpha'_6 H_{it}(T-t) \\ &\quad + \sum_{j=1}^{21} \mu'_j D_j + \sum_{k=1}^6 \theta'_k Y_k + \epsilon'_{it}\end{aligned}\quad (34)$$

The results, together with the expected signs of the coefficients from equations (1) and (2), are presented in Tables 2(a) and 2(b). Notice that the coefficient on $\log(L_{it})$ in the supply equation is not significantly different from zero! A competitive license market would predict a positive sign on α'_1 , with more licenses being supplied when the license price is high; hence, this coefficient estimate is consistent with an imperfectly competitive license market, where such a relation need not be observed. Furthermore, the interaction term $H_{it}(T-t)$ is positive and significant, indicating that a reduction in the numbers equivalent (i.e., an increase in concentration) lowers the supply of licenses in the beginning of the year more than in the latter part of the year. Again, this is suggestive of imperfect competition in the license market.

The demand equation is of less interest here. It suffices to note that the coefficient on $\log(L_{it})$ is negative and significant in this equation, and the coefficient on R_{it} is positive and significant, as expected. Search costs are not an important consideration, since the coefficient on H_{it} is not significantly different from zero. Somewhat surprisingly, the wage variable is also not statistically significant (and wrongly signed.)

TABLE 2(a)
ESTIMATE OF STRUCTURAL EQUATIONS (8). SUPPLY EQUATION

Dependent variable = $\log(S_{it})$

Independent Variable	Coefficient	t Statistic	Expected sign of coefficient*
Constant	6.6071 (0.7544)	8.7585 ^a	
$\log(L_{it})$	0.1103 (0.1533)	0.7195	(+)
C_{it}^{HK}	0.0012 (0.0001)	8.2762 ^a	(+)
$A_{it}/[V_{it}(T-t)]$	6.0910 (1.3702)	4.4455 ^a	(+)
$T-t$	0.5119 (0.0460)	11.1265 ^a	(?)
$(T-t)^2$	-0.0395 (0.0032)	-12.3758 ^a	(?)
$H_{it}(T-t)$	0.0009 (0.0004)	2.0227 ^b	(0)

$R^2 = 0.8547$

Adjusted $R^2 = 0.8471$

21 category dummies and 6 year dummies included.

Number of observations = 662

Standard errors in parentheses.

*From Equation (2) for a competitive model.

^a: Significant at the 1 per cent level.

^b: Significant at the 5 per cent level.

^c: Significant at the 10 per cent level.

^d: Significant at the 20 per cent level.

TABLE 2(b)
ESTIMATE OF STRUCTURAL EQUATIONS (7), DEMAND EQUATION

Dependent variable = $\log(D_{it})$

Independent Variable	Coefficient	t Statistic	Expected sign of coefficient*
Constant	8.4756 (1.2334)	6.8714 ^a	
$\log(L_{it})$	-0.7729 (0.2894)	-6.0911 ^a	(-)
C_{it}^{HK}	0.0001 (0.0002)	0.6689	(-)
R_{it}	0.0479 (0.0130)	3.6967 ^a	(+)
H_{it}	0.0007 (0.0065)	0.1018	(-)

$R^2 = 0.7424$

Adjusted $R^2 = 0.7297$

21 category dummies and 6 year dummies included.

Number of observations = 662

Standard errors in parentheses.

*From Equation (1) for a competitive model.

^a: Significant at the 1 per cent level.

^b: Significant at the 5 per cent level.

^c: Significant at the 10 per cent level.

^d: Significant at the 20 per cent level.

Our estimation of both the structural and reduced forms of the simultaneous equations model thus casts some doubt on the existence of perfect competition in the Hong Kong license market. Both sets of regressions point to the fact that the degree of concentration in license holdings does have a significant impact on the time path of the license prices and quota utilization.

II.6. Conclusion

Our main objective in this paper was to test the hypothesis of perfect competition in the market for apparel quota licenses. Drawing on the simple models in our companion paper, we attempted to model the demand and supply of licenses, taking into special consideration the various components affecting the license price, such as the scarcity component, the option value component, and the asset market component. By introducing an interaction term of the numbers equivalent and the time remaining for the quota to be used, we found that the concentration in license holdings had a significant impact on the equilibrium time paths of the license price and quota utilization. This accords well with the theoretical discussion which points out that the license utilization and price paths with imperfect competition in the license market may be quite different from the corresponding paths in the competitive case, even though the total utilization of licenses remains the same.

Finally, we also estimated the structural demand and supply equations of the model, and this turned up further evidence of imperfect competition in the license market. The supply equation, in particular, was characterized by a statistically significant interaction term, and a price elasticity that was not significantly different from zero.

REFERENCES

- Anderson, J.E. 1987. "Quotas as Options: Optimality and Quota License Pricing under Uncertainty." *Journal of International Economics* 23: 21-39.
- Eldor, R. and A.J. Marcus. 1988. "Quotas as Options: Valuation and Equilibrium Implications." *Journal of International Economics* 24: 255-74.
- Hamilton, C. 1986. "An Assessment of Voluntary Restraints on Hong Kong Exports to Europe and the U.S.A." *Economica* 53: 339-50.
- _____ (ed.) 1990. *Textiles Trade and the Developing Countries*. Washington D.C.: The World Bank.
- Hong Kong Trade Department. 1987. *Textiles Export Control System*. Hong Kong: Government Printer.
- Hong Kong Census and Statistics Department. Various years. *Hong Kong Monthly Digest of Statistics*. Hong Kong: Government Printer.
- Krishna, K., W. Martin and L.H. Tan. 1992. "Imputing License Prices: Limitations of a Cost-Based Approach." Mimeo.
- Morkre, M.E. 1979. "Rent Seeking and Hong Kong's Textile Quota System." *The Developing Economies* 18: 110-18.
- _____. 1984. *Import Quotas on Textiles: The Welfare Effects of United States Restrictions on Hong Kong*. Bureau of Economics Staff Report to the Federal Trade Commission. Washington, DC: U.S. Government Printing Office.
- Textile Asia*, various issues.
- Trela, I. and J. Whalley. 1988. "Do Developing Countries Lose from the MFA?" NBER Working Paper No. 2618. Cambridge, Mass.
- _____. 1991. "Internal Quota Allocation Schemes and the Costs of the MFA." NBER Working Paper No. 3627. Cambridge, Mass.
- Van Wijnbergen, S. 1985. "Trade Reform, Aggregate Investment and Capital Flight." *Economics Letters* 19, pp. 369-372.

END NOTES

1. The operation of the Hong Kong quota system, for example, for textile and apparel exports under the Multi-Fibre Arrangement is documented in Textiles Export Control System, Hong Kong Trade Department (Hong Kong: Government Printer), 1987.
2. Note that other assumptions which result in the same license price realizations (such as supply side uncertainty) can also be used to motivate the model.
3. Specifically, this holds as long as:

$$\delta > \frac{L^L}{\pi L^H + (1-\pi)L^L}.$$

4. For another application of option value see van Wijnbergen (1985).
5. If δ is small enough, then all licenses will be used in Period 1, even if it is a low demand state, and the transaction price will be L^L . In this case, there is no option value component in any period.
6. Note that we are assuming all temporary transfers are used. This is an appropriate assumption as long as the transfer price is positive, since the only reason to buy a license would be to use it. However, if the transfer price is negative, this need not be a good assumption since renewal rights are not sold to the transferee and this creates a moral hazard problem. Transferees have an incentive to "take the money and run". If there is no way to ensure use, then such temporary transfers will not be made; only permanent ones will be made. If temporary transfers are made, then their price will reflect the possibility of losing renewal rights and will exceed the use value of the license.
7. Note that the difference in permanent and temporary license prices is in general equal to the present value of renewal rights as this is the only difference in these two transfer forms.
8. See, for example, Hamilton (1990) which analyzes the effects of the MFA and its proposed reforms from a variety of viewpoints.
9. This is the method used by Morkre (1984), for example, as well as by Trela and Whalley (1988, 1991.)
10. For example, Trela and Whalley (1988, 1991) compute the Hong Kong supply price by subtracting the quota price from the U.S. price. They then compute the production costs of quota-restricted products in other exporting countries by multiplying the unit cost in Hong Kong with the ratio of the exporting country's relative wage in the textile and

apparel industry compared to Hong Kong. However, this approach assumes that the standard competitive model is the appropriate one. Krishna, Martin and Tan (1992) shows that this approach yields significant overestimates of actual license prices, casting into doubt all welfare calculations based on these estimates, as well as the standard static model on which this procedure is based.

11. Textile Asia, February 1989, p.11.
12. Textile Asia, March 1989, p.19.
13. We could also include U.S. costs of production as an explanatory variable since demand for Hong Kong apparel is defined as excess supply over supply from other sources, including the U.S.
14. In a competitive market, U.S. costs, given a license price, should not affect the supply of licenses, although they could affect the demand for licenses, as could the costs in other exporting countries.
15. The reference period is usually the most recent 12-month period for which shipment performance can be ascertained prior to the introduction of the restraint.
16. In the case of finished piece-goods, quotas are allocated on a 40/30/30 basis among the exporter, the finisher and the weaver. In the case of finished fabrics manufactured using imported grey fabrics, quotas are allocated on a 50/50 basis to the exporter and the finisher.
17. This amount was reduced to 35 per cent in June 1985, but was changed back to 50 per cent in July of the following year.
18. MFA category 338/9 is further divided into subcategories 338/9-T (tank tops) and 338/9-O (other.) We have the Herfindahl indices, quota levels and monthly utilizations for the subcategories, but license prices only for the category 338/9 as a whole. Therefore, we had to compute the Herfindahl index for category 338/9 by taking the weighted average (by quota level) of the Herfindahl indices of the subcategories.
19. The log-linear model is simply an approximation. We also ran the model in linear form and obtained essentially the same results.
20. Differentiating (9) w.r.t. H_{it} , we have:

$$\frac{\left(\frac{\partial L_{it}/L_{it}}{\partial t}\right)}{\partial H_{it}} = -\beta_6 = 0.0011.$$

21. Differentiating (8) w.r.t. H_u , we have:

$$\frac{\left(\frac{\partial U_u / U_u}{\partial t}\right)}{\partial H_u} = -\beta'_6 = -0.0007.$$

Policy Research Working Paper Series

Title	Author	Date	Contact for paper
WPS1115 Looking at the Facts: What We Know about Policy and Growth from Cross-Country Analysis	Ross Levine Sara Zervos	March 1993	D. Evans 38526
WPS1116 Implications of Agricultural Trade Liberalization for the Developing Countries	Antonio Salazar Brandão Will Martin	March 1993	D. Gustafson 33714
WPS1117 Portfolio Investment Flows to Emerging Markets	Sudarshan Gooptu	March 1993	R. Vo 31047
WPS1118 Trends in Retirement Systems and Lessons for Reform	Olivia S. Mitchell	March 1993	ESP 33680
WPS1119 The North American Free Trade Agreement: Its Effect on South Asia	Ra'ed Safadi Alexander Yeats	March 1993	J. Jacobson 33710
WPS1120 Policies for Coping with Price Uncertainty for Mexican Maize	Donald F. Larson	March 1993	D. Gustafson 33714
WPS1121 Measuring Capital Flight: A Case Study of Mexico	Harald Eggerstedt Rebecca Brideau Hall Sweder van Wijnbergen	March 1993	H. Abbey 80512
WPS1122 Fiscal Decentralization in Transitional Economies: Toward a Systemic Analysis	Richard Bird Christine Wallich	March 1993	B. Pacheco 37033
WPS1123 Social Development is Economic Development	Nancy Birdsall	April 1993	S. Rothschild 37460
WPS1124 A New Database on Human Capital Stock: Sources, Methodology, and Results	Vikram Nehru Eric Swanson Ashutosh Dubey	April 1993	M. Coleridge-Taylor 33704
WPS1125 Industrial Development and the Environment in Mexico	Adriaan Ten Kate	April 1993	C. Jones 37699
WPS1126 The Costs and Benefits of Slovenian Independence	Milan Cviki Evan Kraft Milan Vodopivec	April 1993	S. Moussa 39019
WPS1127 How International Economic Links Affect East Asia	Vikram Nehru	April 1993	M. Coleridge-Taylor 33704
WPS1128 The International Ocean Transport Industry in Crisis: Assessing the Reasons and Outlook	Hans Jürgen Peters	April 1993	J. Lucas-Walker 31078

Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
WPS1129	How Policy Changes Affected Cocoa Sectors in Sub-Saharan African Countries	Jonathan R. Coleman Takamasa Akiyama Panos N. Varangis	April 1993	G. Ilogon 33732
WPS1130	Poverty and Policy	Michael Lipton Martin Ravallion	April 1993	P. Cook 33902
WPS1131	Prices and Protocols in Public Health Care	Jeffrey S. Hammer	April 1993	J. S. Yang 81418
WPS1132	An Analysis of Repressed Inflation in Three Transitional Economies	Andrew Feltenstein Jiming Ha	April 1993	E. Zamora 33706
WPS1133	Macroeconomic Framework for an Oil-Based Economy: The Case of Bahrain	Ibrahim Elbadawi Nader Majd	April 1993	A. Maranon 31450
WPS1134	Managing a Nonrenewable Resource: Savings and Exchange-Rate Policies in Bahrain	Ibrahim A. Elbadawi Nader Majd	April 1993	A. Maranon 31450
WPS1135	Inflation in Czechoslovakia, 1985-91	Zdenek Drabek Kamil Janacek Zdenek Tuma	May 1993	E. Zamora 33706
WPS1136	The Dynamic Behavior of Quota License Prices: Theory and Evidence from the Hong Kong Apparel Quotas	Kala Krishna Ling Hui Tan	May 1993	D. Gustafson 33714
WPS1137	Railway Reform in the Central and Eastern European Economies	Philip W. Blackshaw Louis S. Thompson	May 1993	TWUTD 31005